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Epidemiology of Burn Injury and Demography of Burn Care Facilities

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Age, occupation, and economic circumstances influence both the incidence of burn injury and the risk of burn death. Flame injury is the most common type of burn for which patients are admitted to burn centers, but scald injuries account for 30% of all burns necessitating admission to the hospital. Approximately 300 burn patients per million population require in-hospital care each year because of extent of burn or presence of a complicating factor. Forty-two per million population per year within that group require care at a burn center, where the personnel, equipment, and facilities necessary to address the multisystem effects of severe burn injury are available. Transfer of burn patients must be coordinated between originating and receiving physicians and is best done as soon as resuscitation has restored hemodynamic and pulmonary stability. The resources required to deliver this complex system of burn care are expensive. Current prospective payment methods result in large reimbursement deficits, and the national trend favoring such payment mechanisms threatens the future of burn centers. (TTD)

EPIDEMIOLOGY

Incidence

The precise occurrence rate of burn injury in the United States is unknown because, except in a few states, burn injury is not a reportable disease. It is commonly estimated that more than two million people sustain burns each year in the United States. Annually there are 6,000 burn- and fire-related deaths, and an additional 500 deaths being attributed to arson or "suspicious circumstances"[1,2] (Table 1).

Burn Hazards

The risk of burn death and burn injury and the frequencies of causative agents are influenced by age, occupation, and economic circumstances. Death by fire and the risk of burn injury are greatest among the economically disadvantaged, apparently as a consequence of residence in older buildings, use of portable, open-flame–type heating equipment, faulty heating or electrical

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systems, crowded living conditions, and absence of smoke detectors. House fire death rates among black people and native North Americans are more than twice those of white people, presumably a reflection of the hazards associated with residence in low-income census areas.[3] House fires account for 75% of all fire and burn deaths, death rates being highest among young children, who have difficulty escaping because of dependency, and the elderly, who have difficulty escaping because of preexisting disease and decreased agility.[2] House fires are more common on weekends, and fatal house fires are most commonly caused by cigarettes.[2,4] More than half of adults who die in house fires have a high blood alcohol concentration.[5] House fires cause only approximately 4% of burn admissions, but the fatality rate among patients hospitalized for burns from conflagrations is higher than for patients with burns from other causes, 12% vs 3%, presumably because of associated inhalation injury.[2]

Clothing ignition is the second leading cause of burn admissions for most ages.[2] In children such burns are most often caused by inappropriate use of matches and lighters.[6] The burn injury rate resulting from the ignition of clothing is highest in low-income census tracts, there being a relation between burn rates and income for burns resulting from ignition of clothing by appliances and equipment.[7] A recent study in Denmark demonstrated that nursing home patients were most frequently burned when unattended as a consequence of fires ignited by cigarettes.[8] The fatality rate among patients with burns resulting from the ignition of clothing is exceeded only by that of patients with burns incurred in house fires.[2] Clothing-related burns caused by synthetic fabrics that melt and adhere to the skin are commonly deeper than burns caused by other agents and often present in a gravity-directed run-off pattern.

Table 1. Burn Injury in the United States

Total burns (estimated)	2,000,000+/yr
Burn and fire deaths	6,500/yr
Burn patients treated in emergency departments	500,000/yr
Hospital admissions for acute burn injury (300/million population)	74,000/yr
Burn center admissions	20,000/yr
Major burns (42/million population)	
Lesser burns with complicating co-factor (40/million population)	

Approximately 112,000 patients with scald burns are seen in hospital emergency rooms annually.[9] Although flame injury is the predominant type of burn for which patients are admitted to burn centers, approximately 30% of all burns necessitating admission of a patient to the hospital are caused by scalds from hot liquids.[2,10] The case fatality for scald injuries is low, but scalds are a major cause of morbidity and associated costs, particularly among children younger than 5 years and among the elderly.[11] One survey found that 45% of all patients in New York State admitted for scalds were children younger than 5 years.[12] Spillage of hot beverages, particularly coffee, is the preponderant cause of scalds among young children. The most common cause of scalds, and of all hospital admissions for burns in the population as a whole, is hot water, including tap water in bathtubs and showers.[2] A recent survey in Denmark revealed that the kitchen is the working place with the highest risk of burns, most commonly as a result of contact with hot liquids.[13]

One epidemiologic study found that in the 15- to 24-year age group the largest number of burn admissions were related to automobiles. Motor vehicle crashes accounted for more than one-fourth of such burns, and steam from automobile radiators was another frequent cause of burn injury.[2] A 1985

review[14] revealed that among patients burned in motor vehicle accidents, 36% had other injuries (most of which were fractures), 36.3% had inhalation injury, and 24.7% died.

Workers in the chemical industry are the single group at greatest risk for chemical burns. Workers involved in the manufacture of phosphate-based fertilizers are at increased risk for burns because they work with strong acids and those who are involved in the manufacture of soap are at increased risk for burns because they work with strong alkali. People who work with etching processes and in petroleum refineries are at greatest risk for injury due to hydrofluoric acid.[15]

Electric current causes 1,100 deaths annually, one-third of which occur in the home and one-fourth of which occur on industrial sites or farms.[2] Young children are at greatest risk of electrical injury from household current as a consequence of inserting uninsulated objects into electrical receptacles or biting or sucking on electric cords and sockets.[1] Burns resulting from low-voltage direct current can be produced by contact with automobile battery terminals and by defective or misused medical electronic equipment, such as electrosurgical devices.[16] Such injuries may be full thickness in character but are typically of limited extent. High-voltage electrical injury is more frequent in white than in black people, presumably because of employment patterns. Electricians, particularly those working for utility companies; construction workers working with cranes; farm workers moving irrigation pipes; oil field workers; truck drivers; and people installing antennae are at greatest risk of high-voltage electrical injury.[17-19] The summertime peak incidence of electrical injury is related to the seasonal intensity of farm irrigation, construction work, and work on outdoor electrical equipment.

Each year 150 to 300 people in the United States are killed by lightning.[20] Approximately one-fifth of lightning deaths occur on farms. Lightning death rates are highest in the Southern and Mountain states. The death rate resulting from lightning injury is highest in the 10- to 19-year age group. As in the case of high-voltage electrical injury, lightning injury is most common during the summer. People in open fields, recreational golfers, fishermen, and campers are at greatest risk for lightning injury.[2]

Fireworks are another seasonal cause of burn injury. The United States Consumer Products Safety Commission estimated that 11,400 people injured by fireworks in 1981 required treatment in hospital emergency rooms.[21] Of those patients, 8.8% required in-hospital care and approximately 60% of the injuries were burns.[22] On the basis of such studies, it can be estimated that 1.86 to 5.82 fireworks-related burn injuries per 100,000 persons occur in the United States during the 4th of July holiday.[23] During the 15-year period 1960 through 1974, 3,628 burn patients were admitted to the United States Army Institute of Surgical Research burn center, of which 4, or 0.1%, had been burned by fireworks.

Roofers and paving workers are at greatest risk for burn injury caused by hot tar. Burns from hot bitumen constitute 16% of all accidents involving roofers and sheet metal workers, 17% of those injuries being of sufficient severity to cause "lost time from work." In 1979, in California alone 366 roofers and slaters sustained burn injuries.[24] Welding is another occupation associated with an increased risk for burn injury, most commonly because of flash burns and explosions, the incidence of which can be reduced if containers are flushed with nitrogen before welding.

Child abuse is a special form of burn injury that is most commonly inflicted by parents but can also be perpetrated by siblings and child care personnel. Factors predisposing to child abuse include teen-aged parents, mental deficits in either the child or the

abuser, unwed motherhood, a single-parent household, and low socioeconomic status, although child abuse occurs in all economic strata. Most victims of child abuse are younger than 2 years and have signs of poor hygiene, psychologic deprivation, and nutritional impairment.[25] Contact burns, caused by cigarettes approximately one-third of the time and often not necessitating admission to a hospital, are the most common form of child abuse thermal injury.[26] Burn injuries caused by placing a small child in a microwave oven are typically full-thickness in depth, sharply demarcated, and present on the body parts nearest the microwave-generating element.[27] Child abuse burns requiring in-hospital care are usually scald injuries, often with associated soft tissue trauma, fractures, and head injury. The characteristic distribution of the scald burn (ie, feet, posterior legs, buttocks, and hands) should alert one to the possibility of child abuse and prompt a thorough evaluation of the circumstances surrounding the injury and the home situation. The importance of such evaluation is emphasized by the fact that if child abuse goes unidentified and the child is returned to the home, there is a high risk of death resulting from repeated injury.[28]

Two studies[29,30] have called attention to burn injuries as a consequence of spousal abuse in which the face or genitalia are intentionally splashed with chemicals or hot liquids and those caused by either abuse or neglect of elderly, disabled, or handicapped adults.

Burn Size

Burn injury elicits the stereotypic biphasic multisystem response that follows any injury.[31] Because the magnitude and duration of organ dysfunction are proportional to the extent of the burn, health care needs increase as the extent of the burn increases. Most burn patients have injuries of such limited extent that they do not require in-hospital care. Even in the population of patients admitted to burn centers, 75% have burn injuries that involve less than 22% of the total body surface.[10,32] This preponderance of minor burns is surprisingly constant, even in situations and populations in which the risk of burn injury is increased, such as mass casualty disasters and military armed conflict.[33]

Table 2. Major Burn Injuries

1. Burns > 10% BSA in patients < 10 or >50 years
2. Burns > 20% BSA in other age groups
3. Burns involving face, hands, feet, genitalia, perineum, or major joints
4. Full-thickness burns > 5% BSA at any age
5. Electrical and lightning burns
6. Chemical burns
7. Inhalation injury
8. Concomitant mechanical trauma
9. Lesser burns with significant preexisting medical disorders

BSA: body surface area.

Regional epidemiologic studies in Florida and central New York state as well as national surveys in Denmark and Uganda[34–37] found that annually approximately 300 burn patients per million population require in-hospital care because of the extent of their burns or a complicating factor, such as an associated injury. Most of these patients are adequately cared for in a general hospital by personnel experienced in burn care. Within this group of burn patients there is an additional subset of patients with major burn injuries (42 per million population per year) and patients with lesser burns and a complicating co-morbid factor (40 per million population per year) (Table 1).

The American Burn Association criteria for major burn injuries are given in Table 2. Patients with major burn injuries are best cared for in a specialized burn center.

Because the extent of a burn is commonly overestimated by persons with limited experience in burn care, it is inevitable that pa-

tients with less than major burns will be hospitalized and even transferred to burn centers. Such overreferral must be expected and accepted to ensure that all patients with major burns requiring burn center care are indeed transferred to such facilities.

Burn Care Needs

The intensity of nursing care, the need for medical specialist care, and the volume of laboratory support are greatest in patients with burns of 50% or more of the total body surface. The nurse-intensive nature of critical burn care is indicated by the data generated in a nursing workload study conducted at the United States Army Institute of Surgical Research burn center during the period January to December 1988.[38] The average daily direct nursing care hours required by the patients in that burn center's intensive care unit (ICU) were 28.3. The need to staff a burn ICU at a level exceeding one nursing service member per patient per day to provide the nursing care required by an extensively burned patient is one of the factors that has promoted the regionalization of burn care facilities.

The multisystem effects of extensive burn injury that result in myriad complications requiring at least consultative, if not direct involvement, of medical specialists are responsible, at least in part, for the frequent siting of burn centers at academic institutions. The medical specialists most frequently involved in the care of patients at burn centers are ophthalmologists, plastic surgeons, orthopedic surgeons, anesthesiologists, cardiologists, radiologists, psychiatrists, and pathologists.

The wide variety and volume of support services required by severely burned patients have also contributed to the development of dedicated tertiary burn centers. Respiratory therapy is required not only during resuscitation, but also during the treatment of postresuscitation pulmonary insufficiency. A planned program of progressive physical therapy and antideformity splinting initiated on admission necessitates involvement of physical therapists and occupational therapists throughout the entire hospital course. Dietetic services are used from the time resuscitation is complete until far into convalescence. Social services are involved in family support throughout hospitalization and in preparing patients for reentry into society. Educational services are used in the convalescent period to minimize injury-related educational lag in burned children.

The laboratory support required by a burn patient varies across time after injury and depends on the extent of the burn, the presence of associated injury such as inhalation injury, and the occurrence of complications. Clinical laboratory support is most intense during the resuscitation period and during the treatment of complications, such as pulmonary insufficiency, fluid and electrolyte disturbances, and metabolic derangements. In addition to epidemiologic surveillance, microbiology support is required for diagnosis and therapeutic monitoring of infections.[39,40] Pathology support is required for accurate assessment of the microbial status of the burn wound as an integral part of the wound biopsy monitoring program.[41]

BURN CARE FACILITIES

In confirmation of the previously noted tendency to overreferral, approximately 90,000 burn patients, who require an average of 12 days care, are admitted to hospitals in the United States annually.[2] Within that group of burn patients, approximately 20,000 meet the criteria of having major burn injuries and are cared for in burn centers. The American Burn Association burn care resources document lists 182 hospitals with self-designated burn care facilities. One hundred forty-six hospitals have burn centers containing 1,790 dedicated burn care beds, and 36 claim specialized burn care pro-

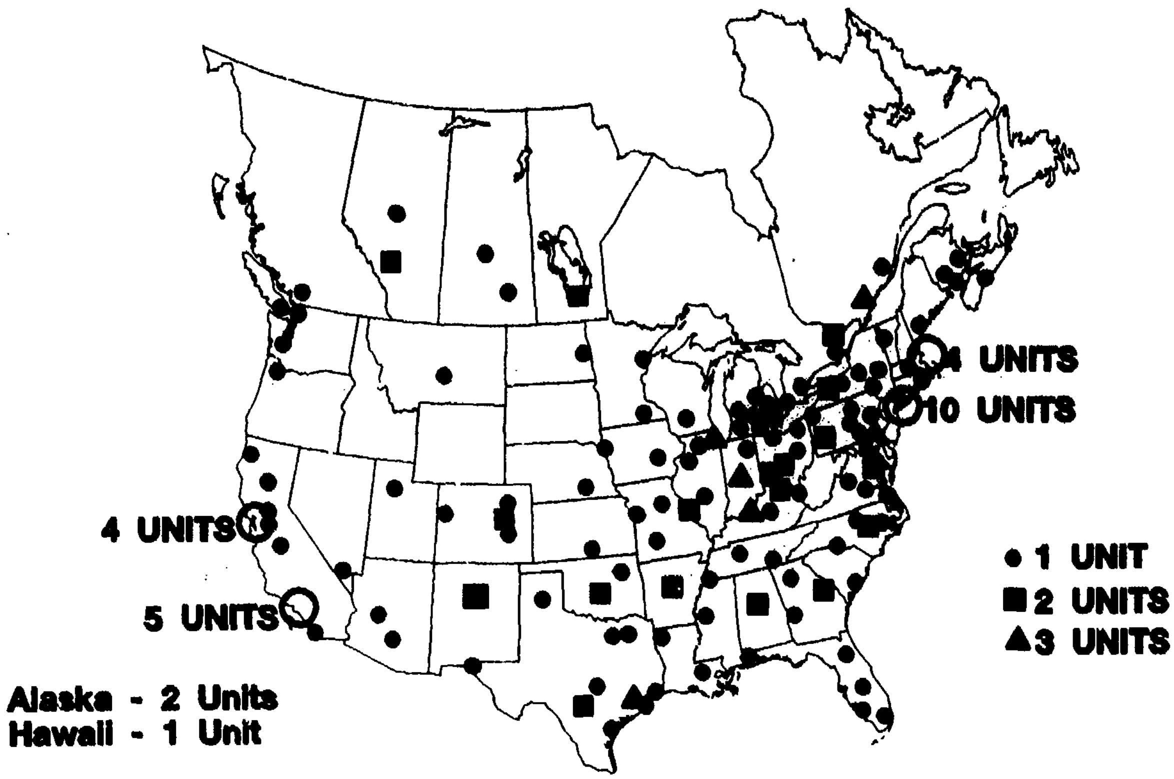

Figure 1. Distribution of burn care centers in the United States and Canada.

grams but no specific burn unit or center. In 1985 approximately 21,000 acutely burned patients were admitted to those burn care facilities. In Canada there are 25 hospitals with self-designated burn centers containing 158 dedicated burn care beds and two additional hospitals with specialized burn care programs but no dedicated burn care beds.[42] Examination of Fig. 1 confirms the regionalization of tertiary burn care facilities in the United States and Canada and also documents that the distribution of those facilities parallels population density. Most burn centers in the United States are located on the Atlantic and Pacific seaboards and in the upper Midwest and Texas, whereas in Canada the burn centers are located in urban areas in the lower latitudes of the provinces.

TRANSFER PROCEDURES

The regionalization of burn care is made possible by and, in fact, depends on a system of timely transfer of patients with major burn injuries to burn centers. Establishment of transfer agreements ensures access to such a system. Patient safety and continuity of care are ensured by physician-to-physician coordination of the transfer procedure. The receiving physician at a burn center should review with the referring physician each of the items listed on a checklist, such as that displayed in Fig. 2, to determine the adequacy of resuscitation, personnel, equipment, and supplies needed to effect transfer; the optimal timing and mode of transfer (ground ambulance vs aircraft); and any necessary modifications of treatment before movement.

With rare exceptions, aeromedical transfer is not required for a burn patient if ground ambulance transfer time is 1 hour or less. When transfer of a patient by ground ambulance would require more time but the patient is still within 150 miles of the burn cen-

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PATIENT TRANSFER INFORMATION

Date and time of call ______________________

Referring MD ______________________ Telephone ____________

Hospital ____________ City ______________ State ____________

PATIENT INFORMATION

Name ____________ SSAN ____________ Status: Active Duty ________
Retired ________
Age ______ Sex ____ Pre-Burn Weight ________ Dependent ________
VAB/BEC ________
Date of burn ________ Cause ________ PHS ________
Civilian ________

Extent of burn ________ 3rd degree ______

Areas burned ______________________

Inhalation injury ______________ Allergies ____________

Associated injuries ______________________

Pre-existing diseases ______________________

TREATMENT CHECK-LIST

Resuscitation: Calculated need (2ml/kg/% TBS) ____________

Fluid in ______________ Urine Output ____________

Airway ________ Blood gases ________ E - T Tube ________

Medications: Analgesics or sedatives ________ Tetanus ________

Antibiotics ________ Other Meds ____________

Escharotomies: Arms ________ Legs ________ Chest ________

Wound Care: Wash and debride ________ Topical Agent ________

Lab tests: HCT ____ Electrolytes ________ Serum Glucose ________ BUN ________

Request: Insert NG tube - Avoid general anesthesia or IM meds
Keep I & O

INFORMATION FOR FLIGHT PLAN

Burn Team ______________ Family to accompany patient ________

Location of nearest airport with jet traffic ______________

Transportation for team at destination ______________

Figure 2. Patient transfer information sheet.

ter, a helicopter is commonly used for transfer. It is particularly important that a burn patient who is to be transferred by helicopter be well stabilized in terms of hemodynamic and ventilatory function before movement. The poor lighting, limited space, vibration, and high noise levels in a helicopter make monitoring difficult and also severely restrict one's ability to carry out emergency therapeutic interventions such as airway intubation or insertion of vascular access lines. When transfer distance exceeds 150 miles, a fixed-wing aircraft is used. The transfer aircraft must be of sufficient size to accommodate a litter and permit continued fluid infusion and continuous ventilatory support, if such are required. The patient area should be of sufficient size to accommodate all equipment and supplies necessary to continue resuscitation and address complications of the injury and therapy, should such arise, during the aeromedical transfer procedure.[43]

Ideally, a physician should be in attendance during the transfer of a patient with a major burn injury. If this is not possible, experienced nonphysician burn unit personnel should be used and all details of patient care and transfer closely coordinated with the receiving physician. The burn flight team used by the United States Army Institute of Surgical Research burn center consists of a surgeon, a licensed practical nurse, and a registered nurse. This group is augmented by a respiratory therapist when assistance in ventilatory management is required during intercontinental transfer procedures.

The burn team is transported to the referring hospital, where evaluation and preflight stabilization of the patient are carried out before movement. A review of management problems encountered in 124 flights, in which 148 burn patients were transferred, revealed that cannula insertion or replacement was the most common intervention required before transfer (87 patients).[44] Placement of a nasogastric tube to reduce the risk of emesis resulting from altitude-related expansion of gas within the gastrointestinal tract was required in 33 patients. Placement of an intravenous cannula was required in 29, placement of a Foley catheter in 13, insertion of an endotracheal tube in eight, and placement of a thoracostomy tube and tracheostomy in two patients each. Alteration of fluid therapy to correct shock or oliguria was necessary in 42 patients before transfer, and alteration of ventilatory support was required in 20: the institution of mechanical ventilation in 16 and the administration of oxygen in four. There were six patients in whom escharotomy of encircling limb burns was required to maintain perfusion of unburned tissue (Table 3). Because preflight stabilization is best performed in the referring hospital, flight line delivery and acceptance of a patient with a major burn injury should be discouraged.

Table 3. Pretransfer Preparation and Stabilization of Burn Patients (148 Patients in 124 Flights)

		Number of Patients
Modification of fluid therapy		42
Cannula and catheter placement or modification		87
Nasogastric tube:	33	
Intravenous cannula:	29	
Urethral catheter:	13	
Endotracheal tube:	8	
Thoracostomy tube:	2	
Tracheostomy tube:	2	
Alteration of pulmonary management		20
Institution of mechanical ventilation:	16	
Administration of oxygen:	4	
Placement of escharotomy incisions		6
Application of wound dressings		38

In-flight treatment needs and management problems recapitulate preflight stabilization problems. A major change in fluid therapy was the most common in-flight in-

tervention and was required in 38 of the previously mentioned 148 burn patients. Inflight ventilatory adjustment was required in seven patients, and 14 required administration of intravenous medications exclusive of analgesics. The frequency of these preflight and in-flight treatment needs indicates the importance of the flight team personnel having available all necessary equipment and supplies throughout the transfer procedure.

The aeromedical transfer of burn patients is best carried out as soon as resuscitation therapy has stabilized hemodynamic and pulmonary function, as indexed by adequacy of tissue blood flow and tissue oxygenation. Later transfer of burn patients may be compromised by postresuscitation complications. Pneumonia, congestive heart failure, cardiac arrhythmias, hyperpyrexia above 39.4°C, and active gastrointestinal hemorrhage are all contraindications to patient transfer that must be addressed and controlled before transfer.[43] Pneumocephalus is an additional contraindication necessitating delay in transfer.

Transfer personnel must be able to recognize the pathophysiologic changes characteristic of burn injury and the common complications of burn therapy and be capable of modifying therapy as necessary both before and during transfer. The continuity and quality of care are optimum when transfer is effected by properly equipped experienced burn care personnel. During the period January 1977 through October 1987, 898 burn patient aeromedical transfers were carried out by the burn flight teams of the United States Army Institute of Surgical Research. Eight hundred seventy-seven flights were conducted within the continental United States to transfer 1,061 patients without a death. Twenty-one intercontinental missions were conducted to transfer 73 burn patients with only two in-flight deaths. One occurred when mechanical ventilation became inadequate in a patient with respiratory insufficiency resulting from severe inhalation injury, and the other occurred when fluid needs were grossly underestimated in a patient attended by non–burn center personnel.

ASSESSMENT OF OUTCOME

The endpoints of burn care are survival, functional recovery, and cosmetic result. The latter two endpoints take precedence in the care of patients with burns of limited extent, and survival is the predominant concern and therapeutic guide in patients with major burns. Survival data also serve as indices of the quality of care and provide a means of evaluating treatments and comparing results with those of other institutions.

Raw survival data not only are meaningless but also are potentially misleading because mortality in burn patients is proportional to the extent of burn and strongly influenced by age. The sigmoid dose–response relation between extent of burn and mortality necessitates mathematical transformation by either probit or logit technique to define a linear relation between the two variables, generate a reliable error term, and facilitate statistical comparisons.[45,46] The effect of age on burn mortality is often dealt with by age-group stratification: 0 to 14 years, 15 to 49 years, and older than 50 years are commonly used groupings. Alternatively, outcome analysis can incorporate a continuous curvilinear function of age.[47]

Assessment of burn patient outcome should be limited to patients received at the individual burn treatment facility within the first 10 days of the injury and treated until discharge or death. The death rate among burn patients is relatively high in the first 10 postburn days and significantly lower thereafter, and it is clearly unwarranted to tabulate as a survivor a moribund patient who is transferred and dies elsewhere. Because the co-morbid effects of concomitant mechanical injury, particularly head injury, are

difficult to quantify, patients with associated injury should be excluded from assays of burn-specific mortality.

Recent studies have documented the mortality-enhancing effects of inhalation injury and infection, particularly pneumonia.[48-50] The effects of those disease processes on mortality among burn patients, dependent on both age and extent of burn, are independent and additive. When comparing outcomes, it is essential that the populations being compared be comparable in terms of presence of inhalation injury and infection and that those co-morbid factors be comparably distributed in relation to age and burn size within the populations. The distribution of burn size within any population of burn patients being assessed must also be considered because a probit curve of the mortality for a population in which small burns predominate may be upwardly biased. A separate outcome analysis should be performed on the subset of patients within that population with burns of more than 40% of the body surface to eliminate such an error.

The LA_{50}, the extent of burn associated with death in half of the patients with burns of that extent, is the statistic commonly used for outcome assessment. Comparison of current LA_{50}s with those of 40 years ago confirms the improvement in burn patient survival that has occurred among the young adult and older adult age groups over the last four decades. In the mid-1940s the LA_{50} (by probit analysis) was 43% for young adults and 23% for older adults as compared with 60.8% and 39.2%, respectively, at the United States Army Institute of Surgical Research during the years 1979 to 1983.[51] A similar improvement in survival rates has been reported at pediatric burn centers, ie, an LA_{50} of 51% in the 1940s compared with the 93% rate recently reported in 1986 by one such center.[52] This increase in survival rate represents the aggregate effect of nonspecific improvements in the care of critically ill patients over four decades, the benefits of specialized care and research at regional burn centers, and the effective transfer system that ensures that patients with major burns are referred to burn centers in a timely manner.

Table 4. Burn Center Staffing Requirements

Director
Associate director
Fellow
Residents: 2 for every 15 patients
Nurses: 1 for every 2 ICU patients
Clinical nurse instructor
Occupational therapists: 1 for every 10 patients
Physical therapist: 1 for every 7 patients
Social worker: Full-time assignment to burn center
Nutritionist
Respiratory therapist: 24 hours per day, 7 days per week

(Modified from standards of Burn Advisory Committee, New York City Emergency Medical Services, 1988.)

ECONOMICS OF BURN CARE

Burn centers were the first successful implementation of the specialty referral center concept. The first burn center was established at the United States Army Surgical Research Unit and opened in 1950. Since that time, this concept has been expanded to create trauma centers, limb replantation centers, and spinal cord injury centers. Although the specialty referral center is the most efficient method to deliver expert medical care for these specific acute medical problems, the expense to the institutions supporting these centers is enormous.

Service standards for specialized burn facilities have been established by a number of accreditation agencies at the local, state and national levels. Individual standards require unit organization and integration with other units in the supporting institution, delineated responsibilities of the staff according to special patient-care needs, education, po-

licies and procedures for patient care, and guidelines for facility design and equipment.[53,54] Required personnel reflect the true interdisciplinary composition of a full-service burn center, the major emphasis being on continuous individualized burn care (Table 4). In addition, physician consultative services from all major clinical departments must be readily available at all times.

Severe burn injury is a chronic disease of which hospitalization for acute burn care is only the initial phase. Absolutely implicit in the decision to establish a burn center is the obligation to provide burned patients with the long-term care required before the burn and all of its sequelae have healed and the patient has reentered society productively. Outpatient follow-up care is often long term and may span 4 or 5 years for children with severe burns. Major treatment programs for outpatients include control of burn scar hypertrophy and contractures, treatment of postinjury stress disorders, provision of social worker and home health support, and patient and family education (both in burn care and burn prevention). Without this long-term care, the benefits of acute treatment are often lost.

Costs of Burn Center Care

The costs of burn center care have proved to be relatively elusive to define. One problem has been the diversity of recognized burn treatment facilities, which range from four-bed units to centers with more than 40 beds. It is likely that burn facilities begin to approach economic efficiency at the size of an eight- to ten-bed unit, given the multidisciplinary personnel needed for burn care. Smaller facilities often experience great difficulty in routinely keeping these expensive beds filled and the dedicated staff intact.

The New York Hospital Burn Center is an example of an urban burn care facility servicing the population predominantly of the greater New York City metropolitan area. It consists of a 24-bed ICU floor and a 22-bed step-down area. Census ranges from 35 to 75 patients, with a mean inpatient load of approximately 50 patients. The ICU is configured so that the patients requiring complex monitoring and nursing care are located in half of the ICU, whereas those who are recovering gradually move toward the other half as their conditions improve. Although the latter beds are less densely equipped, all are configured to provide full ICU-level support. The step-down floor is also staffed as described in Table 4 and is engineered so that it can act as a primary burn ICU in the event of a mass casualty incident. In this way, bed occupancy can be maintained while resources and staff are distributed in the most efficient manner. Activity of nursing care is extremely high for massively burned patients and may require one nurse assigned to each of these critically ill patients. Sovie et al[55] found that the proportion of patient days requiring category 3 and 4 nursing intensity (on a four-part nursing intensity scale) was more than 93% for extensively burned patients. Both of the categories entail one-on-one staffing assignments.

Table 5. Distribution of Routine Service Costs of a University Burn Center, New York Hospital, 1988

Expense	Percentage
Personnel	43
Medical supplies	17
General administration	14
Unit administration	5
House staff	4
Central services	3
Laundry	3
Other	15

As is evident, salaries and benefits for clinical personnel are the largest proportion of the operating cost in the burn center (Table 5). The smaller unspecified costs include medical records, dietary support, house-

Table 6. Ancillary Service Utilization of a University Burn Center, New York Hospital, 1988 (Average Cost Per Case [$])

DRG	Lab	Radiology	Blood	Special	OR/RR	Pharmacy	Miscellaneous	Total
456	765	451	207	394	349	432	66	2,664
457	1,610	746	661	369	50	696	0	4,133
458	4,439	2,262	1,339	2,284	1,923	3,463	317	16,027
459	1,974	972	846	534	401	1,204	46	5,976
460	1,071	524	136	314	36	495	11	2,587
472	4,997	2,327	2,249	2,175	1,935	3,175	617	17,474
474	16,290	8,097	2,013	4,988	1,341	14,776	922	49,056

DRG: diagnosis-related group; OR: operating room; RR: recovery room.

keeping, legal affairs, and operation and maintenance of the physical plant. In 1988, service costs averaged $1,194 per day per patient in the New York Hospital burn center. Ancillary costs depended on the classification of the patient's injuries (Table 6). In general, the more extensive the thermal and associated injuries, the more costly they were. Tables 5 and 6 do not reflect equipment and other capital costs or depreciation of the physical plant.

Reimbursement

The adequacy of reimbursement in the long term determines whether or not a burn center can survive. The demographic profile of a population of burn patients usually reflects a significant bias toward the less economically advantaged (Table 7). In states without regulatory control of hospital reimbursement, significant cost shifting likely plays a role in funding for underinsured or noninsured patients. Commercial carriers usually pay all charges, whereas Blue Cross and Medicare often have restrictions or limits on paying hospital bills. In some states Medicaid pays very little, and self-pay patients usually are indigent. Table 7 illustrates the tendency for severely burned patients in the ICU to be the major financial risks to hospitals with burn centers. Until recent years, cost shifting has been the traditional method for paying for underreimbursed burn care. During the last decade, prospective payment plans have emerged as the alternative and increasingly dominant method for hospital reimbursement. Under these models, cost shifting is rarely feasible, and the financial success or failure of a hospital and its burn center critically depends on the fixed reimbursement rate covering the costs of patient care.

Table 7. Burn Center Payer Class Distribution (New York Hospital, January 1989 through July 1989, 650 Admissions)

	ICU (%)	Step-Down Unit (%)
Medicare	12.4	13.5
Medicaid	39.3	35.6
Blue Cross	13.3	14.6
Commercial	22.8	27.4
Self-pay	12.2	8.9

ICU: intensive care unit.

Reimbursement based on the patient's diagnosis is the major prospective payment system used by funding agencies. Diagnosis-related groups (DRGs) were developed in the 1970s initially as a tool for utilization review. Hospitalized patients were classified according to patterns of care received, lengths of stay, and use of services. The original 383 DRGs recognized only the presence or absence of a secondary diagnosis and did not recognize the variable severity of an ill-

Table 8. DRGs Associated With Thermal Injury

Cutaneous Burn

456—Burn patient transferred to another acute care facility
457—Extensive burns without OR procedures
458—Nonextensive burn with skin grafts
459—Nonextensive burns with wound debridement and other OR procedures
460—Nonextensive burns without OR procedures
472—Extensive burn with OR procedures

Inhalation Injury

101—Other respiratory system diagnosis
474—Respiratory system diagnosis with tracheostomy
475—Respiratory system diagnosis with ventilatory support
736—Tracheostomy other than for mouth, larynx, or pharynx disorder

DRGs: diagnosis-related groups; OR: operating room.

ness within broad disease categories. Additional DRGs have been added during the last decade, and the current number exceeds 700.

Each DRG is assigned a case mix index (CMI), which is a weighted average service intensity multiplier that theoretically reflects relative resource consumption associated with each DRG. The higher the index, the more seriously ill the patient is, and the greater are the hospital revenues. Each DRG is characterized by an expected length of stay (LOS) based on statistical evaluation of that disease complex in the past. Long stay outliers occur when actual LOS exceeds the expected LOS of the patient's DRG by 20 days or 1.94 standard deviations, whichever is less. Cost outliers are derived in the same manner based on the reimbursement rate for each DRG.

There are six burn categories ranging from DRG 456 to the new DRG 472, which was added in October 1986 (Table 8). In addition, four additional DRGs are frequently used for patients with inhalation injury, with or without cutaneous burns. The burn DRGs are based only on extent of burn injury and the occurrence of a surgical procedure. A nonextensive burn can be as large as 49% total body surface area (TBSA) if it is all second degree, and an extensive burn can be as small as 20% TBSA if it is all third degree. Debridement that uses surgical excision qualifies for inclusion into DRG 459, whereas hydrotherapy or enzymatic debridement for wound care is not classified as an operative procedure. Furthermore, a number of procedures performed in appropriately equipped and staffed burn centers qualify as operating room procedures. These procedures include tracheostomy, escharotomy, and fasciotomy. Together, the combinations of burn extent and operative status result in 279 ICD-9-CM codes (International Classification of Disease, version 9, Clinical Manual).

Each DRG is associated with a fixed reimbursement rate, and certain strategies to secure optimal reimbursement are evident (Table 9). Since October 1988, new codes require medical coders to distinguish between

Table 9. Weight Factors and Reimbursement Rates of Burn-Related DRGs

DRG	Relative Weight	Expected LOS (days)	Reimbursement Rate ($)
456	5.5044	8	24,061
457	5.3930	17	23,574
458	6.5200	24	28,502
459	3.0963	10	13,535
460	1.3967	8	6,105
472	20.3751	36	89,064
101	1.3539	10	5,918
474	12.3838	45	54,132
475	5.0545	14	22,094
736	16.8390	48	73,610

LOS: length of stay; DRG: diagnosis-related group; CMI: case mix index.

New York State Guidelines, 1988, except for DRG 474, which was calculated from HCFA relative weight.

excisional debridement (ICD-9 code 86.22) and nonexcisional debridement (86.28). If excisional debridement is performed, it must be documented in the patient's medical record; there is a significant difference in the reimbursement rates for DRG 459 and DRG 460 (Table 9). If a patient has both a thermal burn and severe inhalation injury, coding the primary diagnosis as inhalation injury or as a cutaneous burn may have a considerable impact on reimbursement. Thus, it is important to document inhalation injury on admission by bronchoscopic examination or xenon ventilation–perfusion lung scan.

The effect of the initial five burn DRGs (456–460) was evaluated in 275 severely burned patients admitted to the New York Hospital Burn Center in 1983.[56] Charges were documented by the billing department. In addition, the costs of burn care for each of these 275 patients were collected by prospectively following each patient's clinical course during hospitalization. These costs included direct costs, indirect costs, overhead, and ancillary services. Direct costs included all clinical personnel and materials for the care of patients on the burn unit. Indirect costs included labor and supply components of the service departments contributing to burn patient care. The step-down cost allocation method was used to determine the overhead and housekeeping components of the burn unit. Ancillary service costs were obtained by documenting each patient study or treatment and calculating costs using the cost-to-charge ratio for each event.

The step-down cost allocation method, however, reflects accounting costs and not true economic costs. Except for that of ancillary services, all other costs were measured directly either from purchase orders or from hours worked and pay rates.

Daily costs in 1983 averaged $1,216 per patient, whereas hospital daily charges were only $830. Assuming that DRG reimbursement was received for every patient (and this certainly was not the situation because of the large number of worker's compensation and indigent patients), the average payer rate would have been $573 per patient per day, or a real loss of $643 per patient per day. A major cause of per-patient loss (in addition to that for indigent patients) was the proportion of the total hospitalization that was attributed to LOS outliers in Medicare and Medicaid patients (73% and 49%, respectively).

The ability of the five burn DRGs to explain the variation in resource consumption was further examined in the 400 evaluable burned patients admitted in 1983, including the 275 patients described earlier.[57] The cost data, not charges, were evaluated by a simple analysis of variance to assay degree of variation within each DRG and by a reduced form model relating resource consumption to clinical and nonclinical factors. The burn DRGs explained only 17% of the variation of resource consumption, which is lower than other DRGs or competing classification methods.

Uncaptured components of patient severity, especially inhalation injury and larger body surface area burns, explain much of the residual variation within each DRG. Age is positively related to resource consumption ($P < .05$). For patients between the ages of 20 and 65 years, a 10% increase in age was associated with a 4% increase in resource consumption. The observable differences in patient severity within each burn DRG allow hospitals without specialized burn facilities to select and transfer nonprofitable patients to regional specialty units, greatly increasing that center's financial risk.

Since this analysis, numerous changes have been made in the DRG method that have benefited burn centers. In 1986, DRG 472 was added, allowing greater reimbursement for massive burns undergoing surgical procedures. In 1987, DRGs 474 and 475 were added. Those two DRGs allow higher reimbursement rates for patients with severe

Table 10. Case Mix Index by Payer Status

	Number of Patients	CMI	Actual LOS	Expected LOS
ICU patients				
Medicare	46	3.09	29.5	10.3
Medicaid	145	3.73	13.5	10.8
Blue Cross	49	5.29	13.9	14.1
Commercial	84	2.47	9.4	8.3
Self-pay	45	5.91	7.9	14.4
Step-down unit patients				
Medicare	38	2.65	24.1	11.1
Medicaid	100	3.62	22.3	10.6
Blue Cross	41	3.22	14.5	10.1
Commercial	77	3.28	11.6	10.43
Self-pay	25	4.78	16.8	12.9

LOS: length of stay in days; ICU: intensive care unit.
New York Hospital, January 1989 through July 1989.

inhalation injury, who incur greater patient care costs than those with cutaneous burns. In addition, the *Budget Reconciliation Act of 1987* increased outlier payments for burn DRGs from 60% to 90%.[58] Finally, in 1988 DRG 736 was added, but it applies only to non-Medicare patients; in an all-payer state system, DRG 474 is the equivalent DRG for Medicare patients.

In 1988, New York State introduced the All Payor DRG Program. With this new law, all hospital reimbursement agencies are required to use established fixed payment schedules (Table 9). Medicare patients continue to be funded under guidelines set by the federal government, whereas all others follow New York State guidelines. The fixed rate of the latter system is moderately higher than that for Medicare, but LOS outlier payments are greatly reduced. Indigent care continues to remain unfunded.

These new reimbursement guidelines have considerable impact on burn center reimbursement. The elderly and indigent are responsible for disproportionately high excessive LOS and severity of illness indices (Table 10). The indigent (self-pay) CMI is four times the mean CMI for the hospital overall. Even when a severely burned patient is covered by a third-party payer, patient care costs far outstrip the DRG fixed-rate reimbursement. The mean LOS for DRG 472 was 70 days in the New York Hospital Burn Center in 1988. Using the mean LOS for that DRG and its burn center daily rate plus ancillary costs from Tables 6 and 9 (mean LOS × daily rate + ancillary services), the average hospital cost for DRG 474 was $118,309; by comparison, actual reimbursement was only $54,132, a considerable loss for the hospital.

Diagnosis-related group outlier policy is flawed because it assumes that the costs of treating patients decrease near the end of a hospital stay. In reality, severely burned patients require expensive care until the end of hospitalization. Severe illnesses remain uncaptured in the current DRG structure. Age and inhalation injury greatly influence burn management and are major determinants of survival.[57,59] The high costs of the ICU environment, especially if a patient requires mechanical ventilatory assistance, almost uniformly cause great financial losses for the hospital.[60,61]

Burn centers continue to be a major source

of financial loss for hospitals that support them.[62] The effects of the new DRG 472 are not yet evident, but its addition to the DRG method reduces the magnitude of hospital deficits but likely does not eliminate them. New technologies in wound care have proved cost effective.[63] However, financial solvency will require major changes in current prospective methods before burn center care, with all its advantages for improved patient care and survival, becomes financially neutral. At this time, a reorganization of the present DRG system is being considered, which would redefine and expand the number of DRGs to 1,200 with classification that would recognize the severity of a patient's condition and complications.[58] Until such a system is accomplished, burn centers will continue to close.

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